

## MP106E M-235 Linear Actuators User Manual

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**This document describes the following high-load precision linear actuators with recirculating ball screws:**

- M-235.22S:  
Travel Range 20 mm, Stepper Motor
- M-235.2DD:  
Travel Range 20 mm, DC Direct Drive
- M-235.2DG:  
Travel Range 20 mm, DC Gear Motor
- M-235.2VD:  
Travel Range 20 mm, DC Direct Drive, Vacuum-Compatible
- M-235.2VG:  
Travel Range 20 mm, DC Gear Motor, Vacuum-Compatible
- M-235.52S:  
Travel Range 50 mm, Stepper Motor
- M-235.5DD:  
Travel Range 50 mm, DC Direct Drive
- M-235.5DG:  
Travel Range 50 mm, DC Gear Motor
- M-235.5VD:  
Travel Range 50 mm, DC Direct Drive, Vacuum-Compatible
- M-235.5VG:  
Travel Range 50 mm, DC Gear Motor, Vacuum-Compatible



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Subject to change without notice. This manual is superseded by any new release. The latest release is available for download on our website (<http://www.pi.ws>).



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# 1 About this Document

## In this Chapter

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## 1.1 Goal and Target Audience of this Manual

This manual contains information on the intended use of the M-235.

It assumes that the reader has a fundamental understanding of basic servo systems as well as motion control concepts and applicable safety procedures.

For updated releases of this user manual, or if you have any questions, contact our customer service department (p. 39).

## 1.2 Symbols and Typographic Conventions

The following symbols and typographic conventions are used in this user manual:

### CAUTION



#### Dangerous situation

If not avoided, the dangerous situation will result in minor injury.

- Actions to take to avoid the situation.

### NOTICE



#### Dangerous situation

If not avoided, the dangerous situation will result in damage to the equipment.

- Actions to take to avoid the situation.

### INFORMATION

Information for easier handling, tricks, tips, etc.

| Symbol        | Meaning   |
|---------------|---|
| 1.<br>2.      | Action consisting of several steps whose sequential order must be observed                |
| ➤             | Action consisting of one or several steps whose sequential order is irrelevant            |
| ■             | List item   |
| p. 5          | Cross-reference to page 5   |
| <b>RS-232</b> | Labeling of an operating element on the product (example: socket of the RS-232 interface) |

## 1.3 Other Applicable Documents

The devices and software tools which are mentioned in this documentation are described in their own manuals.

For the latest versions of the user manuals contact our customer service department (p. 39).

| Controller                             | Document           |
|--|--------------------|
| C-843 DC-Motor Controller PCI PC Board | MS77E User Manual  |
| C-863.10 DC-Motor Controller           | MS173E User Manual |
| C-863.11 DC-Motor Controller           | MS205E User Manual |
| C-663.10 Stepper Motor Controller      | MS138E User Manual |
| C-663.11 Stepper Motor Controller      | MS208E User Manual |

## 2 Safety

### In this Chapter

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### 2.1 Intended Use

The M-235 is a laboratory device as defined by DIN EN 61010-1. It is intended to be used in interior spaces and in an environment which is free of dirt, oil, and lubricants.

Based on its design and realization, the M-235 is intended for positioning, adjusting and shifting loads in one axis at various velocities.

The intended use of the M-235 is only possible when installed and with a suitable controller (p. 12). The controller is not included in the scope of delivery of the M-235.

### 2.2 General Safety Instructions

The M-235 is built according to state-of-the-art technology and recognized safety standards. Improper use can result in personal injury and/or damage to the M-235.

- Only use the M-235 for its intended purpose, and only use it if it is in a good working order.
- Read the user manual.
- Immediately eliminate any faults and malfunctions that are likely to affect safety.

The operator is responsible for the correct installation and operation of the M-235.

## 2.2.1 Organizational Measures

### User manual

- Always keep this user manual next to the M-235.  
If the user manual is lost or damaged, contact our customer service department (p. 39).
- Add all information given by the manufacturer to the user manual, for example supplements or Technical Notes.
- If you pass the M-235 on to other users, also turn over this user manual as well as all other relevant information provided by the manufacturer.
- Only use the device on the basis of the complete user manual. Missing information due to an incomplete user manual can lead to slight injury as well as property damage.
- Only install and operate the M-235 after having read and understood this user manual.

### Personnel qualification

The M-235 may only be started up, operated, maintained and cleaned by authorized and qualified staff.

## 2.2.2 Measures for Handling Vacuum-Compatible Products

When handling the vacuum version of the linear actuator, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. During assembly and measurement, powder-free gloves are worn. Afterwards, the linear actuator is cleaned once again by wiping and shrink-wrapped twice in vacuum-compatible film.

- Only touch the linear actuator with powder-free gloves.
- If necessary, wipe the linear actuator clean after unpacking.

## 2.2.3 Safety Measures during Installation

A cable break leads to a failure of the linear actuator.

- Install the linear actuator so that the cable is not bent or squeezed too severely during operation.

The motion of the pusher can be hindered by a mounting nut that has been tightened too strongly. This reduces the positioning accuracy.

- Tighten the mounting nut to a maximum torque of 1 Nm.

Lateral forces that affect the pusher of the linear actuator increase the friction on the internal drive components. Increased friction impairs the motion of the pusher and increases wear on the drive components.

- Avoid lateral forces on the tip and on the pusher of the M-235.

While the end piece is being screwed on or off, the torque is transferred to the drive of the linear actuator via the pusher and can damage the drive.

- Avoid torques to the pusher.
- When screwing an end piece on or off, attach the pusher to the wrench flats using an open-end wrench.

The heat produced during operation of the M-235 can affect your application.

- Install the M-235 so that your application is not affected by the dissipating heat.

## 2.2.4 Safety Measures during Start-Up

A motorized linear actuator can generate powerful forces depending on the gear ratio.

Connecting a linear actuator to an unsuitable controller can cause damage to the linear actuator or controller.

- Connect a linear actuator with DC motor to a DC motor controller only.
- Connect a linear actuator with stepper motor to a stepper motor controller only.

Faulty motor controllers can cause unintentional motor motion and run the M-235 into the hard stop.

The linear actuator can perform an unintentional motion when connecting it to the motor controller.

- Do not place any objects in areas where they can get caught by moving parts.
- Keep your fingers at a safe distance from the motion range of the M-235.

The collision of moving parts with the hard stop (end of travel range), as well as high acceleration, can cause damage to, or considerable wear on the mechanical system.

- In the event of a malfunction of the motor controller, stop the motion immediately.
- Ensure that the end of the travel range is approached at low velocity.
- Set your control signal so that the moving part does not stop abruptly or try to continue moving at the end of the travel range.
- Determine the maximum velocity for your application.
- Ensure that the automatic limit switch halt is supported by the controller, or that it is activated in the controller.

### 2.2.5 Safety Measures during Operation

For models with DC motors:

Unsuitable settings made to the servo-control parameters can impair the performance of the M-235. The consequences of this can be expressed as follows:

- Oscillations
- Imprecise approach of the position
- Settling time is too long
- If the performance of the M-235 is not satisfactory, check the settings for the servo-control parameters of your controller.

### 2.2.6 Safety Measures during Maintenance

The M-235 is precisely aligned.

- Do not loosen any sealed screw.

# 3 Product Description

## In this Chapter

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## 3.1 System Overview

The following figure shows an overview of the total system.

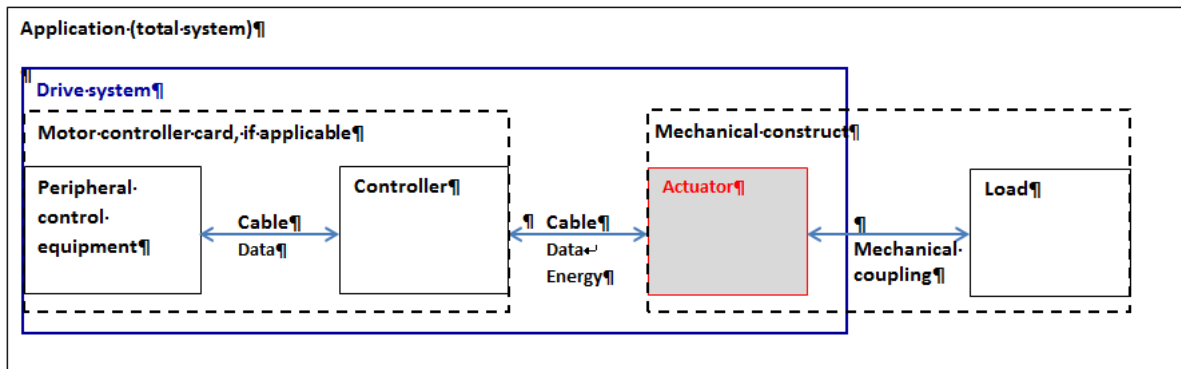


Figure 1: Overall system, overview

To operate the actuator in your application, the following components are necessary:

| Component                    | Task  | Supplied by or available from PI   |
|------------------------------|---|--|
| Peripheral control equipment | Loads configurations and control commands to the controller (e.g. PC in connection with PC software).   | PC software (e.g. PIMikroMove) included in the scope of delivery of PI controllers.  |
| Controller                   | Controls the motions of the actuator.   | Stand-alone device or motor controller card (PC add-on card). Available separately, see section "Suitable Controllers" (p. 12).  |
| Actuator                     | Produces the motions of the part to be driven or the load in your application.  | Here: linear actuator, type M-235. Present product.  |
| Cables                       | <ul style="list-style-type: none"> <li>Peripheral control equipment to controller: Ensures the data communication.</li> <li>Controller to actuator: Ensures the data communication and the power source of the actuator.</li> </ul> | <ul style="list-style-type: none"> <li>Transmission cable between PC and controller. Included in the scope of delivery of PI controllers.</li> <li>Transmission cable between controller and actuator: Part of the actuator or included in the scope of delivery of the piezo actuator.</li> </ul> |

| Component            | Task   | Supplied by or available from PI  |
|----------------------|--|---|
| Mechanical structure | Ensures among other things the secure fixation of the actuator and thus a high repeatability.                            | Only mounting nut (for mechanical connection) included in the scope of delivery of the actuator.                                  |
| Mechanical coupling  | Establishes the connection between the actuator and the load (pusher with a separate end piece, depending on the model). | Also in case exchangeable parts can be used, all options are included in the scope of delivery of the actuator (e.g. end pieces). |
| Load                 | Part to be driven. This is to be moved in your application.  | -   |

If a motor controller card is used, the "controller" component and the connection between the peripheral control equipment and the controller ("cable") are physically inside of the PC.

## 3.2 Features and Applications

The motorized precision drives of the M-235 series are linear actuators with travel ranges of 20 mm or 50 mm. They stand out thanks to their high positioning resolution, load capacity, velocity and lifetime in industrial applications. Their design with a low-friction and backlash-free ball screw enables loads of up to 120 N to be moved with minimum incremental motions of up to 100 nm (M-235.xxG and M-235.xxS models) or 500 nm (M-235.xxD models). The non-rotating end piece avoids wobbles and supports very uniform motions.

Integrated limit and reference point switches, plus line drivers enable the simple installation in automation solutions and protect the mechanical system of the actuator.

### 3.3 Model Overview

Ten standard versions of the M-235 are available. All models are high-performance linear actuators with a ball screw. They differ in terms of:

- Travel range
- Drive type
- Suitability for operation in vacuum

| Model     | Travel range |       | Drive type |              |               | Vacuum suitability<br>(to 10 <sup>-6</sup> hPa) |
|-----------|--------------|-------|------------|--------------|---------------|---|
|           | 20 mm        | 50 mm | DC direct  | DC gear-head | Stepper motor |   |
| M-235.22S | +            |       |            |              | +             |   |
| M-235.2DD | +            |       | +          |              |               |   |
| M-235.2DG | +            |       |            | +            |               |   |
| M-235.2VD | +            |       | +          |              |               | +   |
| M-235.2VG | +            |       |            | +            |               | +   |
| M-235.52S |              | +     |            |              | +             |   |
| M-235.5DD |              | +     | +          |              |               |   |
| M-235.5DG |              | +     |            | +            |               |   |
| M-235.5VD |              | +     | +          |              |               | +   |
| M-235.5VG |              | +     |            | +            |               | +   |

- .For further technical data, see the specifications (p. 41).

PI also produces custom designs upon request. Custom designs can differ from the described standard products in respect to dimensions, characteristics or other technical data.

- If necessary, contact our customer service department (p. 39) directly.

### 3.4 Product View

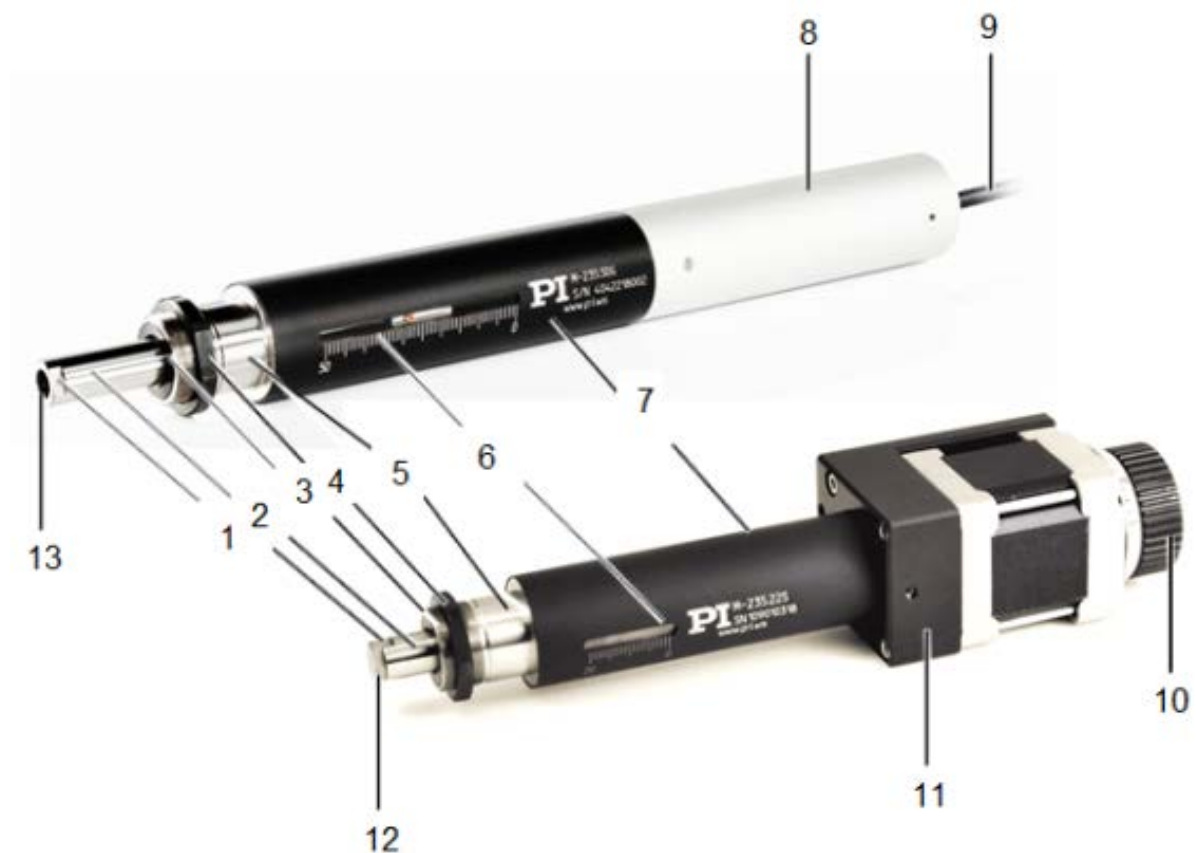


Figure 2: Product view M-235 (in front: M-235.22S version, behind: M-235.5DG version)

- 1 Wrench flat of the pusher
- 2 Pusher, non-rotating
- 3 M20 thread for mounting nut
- 4 Mounting nut for clamp connection
- 5 Mounting shaft
- 6 Window with position display
- 7 Sleeve for micrometer assembly
- 8 Sleeve for DC motor
- 9 Cable for connecting to the controller
- 10 Hand wheel for manually moving the pusher inwards and outwards
- 11 Stepper motor case with panel plug (not visible here) for connecting to the controller
- 12 End piece, flat
- 13 Hole with M6 thread, 10 mm deep for integrating the end piece

### 3.5 Scope of Delivery

| Order Number | Items   |
|--------------|---|
| M-235        | linear actuator according to order (p. 10), with flat end piece (assembled on delivery) and spherical end piece |
| C-815.38     | Motor Cable, 3 m, Sub-D, 15-pin (m/f)   |
| MP106E       | User manual (this document) in printed form   |

### 3.6 Suitable Controllers

The M-235 must be connected to a suitable controller. The following controllers from PI are suitable for the operation of the M-235:

| Drive Type    | Controller | Axes per Controller | PC-Interface             | Multiple Controllers on the Same PC |
|---------------|------------|---------------------|--------------------------|-------------------------------------|
| DC motor      | C-843      | 2 or 4              | Internal (PCI bus)       | Yes, separate boards                |
|               | C-863      | 1                   | USB, RS-232, daisy chain | Yes, same interface                 |
| Stepper motor | C-663      | 1                   | USB, RS-232, daisy chain | Yes, same interface                 |

The required PC software is included in the scope of delivery of the PI controllers. The operation of the controllers is described in the corresponding user manuals.

The operating parameters must be adjusted depending on the version of the M-235 used (p. 29).

## 3.7 Accessories

| Order Number | Description   |
|--------------|---|
| C-842.AP1    | Adapter box PWM analog to operate M-235 linear actuators with PWM signals |
| C-815.83     | Motor cable 10 m, Sub-D, 15-pin (m/f)                                     |
| C-815.38V    | Motor cable vacuum, 3 m, sub-D, 15-pin (m/f)                              |
| C-815.VF     | Vacuum feedthrough, sub-D, 15-pin (m/f)                                   |

To order, contact our customer service department (p. 39).

## 3.8 Technical Features

### 3.8.1 Rotary Encoder

The models with DC motors are equipped with a rotary encoder. A rotary encoder, also called an incremental or incremental rotary encoder, is implemented at a rotating point in the drivetrain, e.g. the motor shaft. To determine the relative position, the controller counts the encoder signals, the so-called impulses.

### 3.8.2 Limit Switches

The M-235 is equipped with non-contact, Hall-effect limit switches.

Each limit switch sends an overtravel signal on a dedicated line to the controller. The controller then stops the motion. If the controller does not stop the motion in time, the linear actuator runs into the hard stop.

See "Limit Switch Specifications" (p. 43) for more information.

### 3.8.3 Reference Point Switch

The M-235 is equipped with a direction-sensing reference point switch, which is located at about the midpoint of the travel range. This sensor sends a TTL signal indicating whether the linear actuator is on the positive or negative side of the reference point switch.

The rising or falling edge of this signal can be used to indicate a known reference position. The difference in the reference points when approached from the positive or the negative side is about 0.2 mm to 0.4 mm.

See the controller user manual and/or associated software manuals for the commands which make use of the reference point signal.

For further details, refer to the "Specifications" section (p. 41).

## 4 Unpacking

### INFORMATION

When handling the vacuum version of the linear actuator, attention must be paid to appropriate cleanliness. At PI, all parts are cleaned before assembly. During assembly and measurement, powder-free gloves are worn. Afterwards, the linear actuator is cleaned once again by wiping and shrink-wrapped twice in vacuum-compatible film.

- Only touch the linear actuator with powder-free gloves.
- If necessary, wipe the linear actuator clean after unpacking.

1. Unpack the M-235 with care.
2. Compare the contents against the items covered by the contract and against the packing list.
3. Inspect the contents for signs of damage. If parts are missing or you notice signs of damage, contact PI immediately.
4. Keep all packaging materials in case the product needs to be returned.



## 5 Installation

### In this Chapter

|  |    |
|--|----|
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| Changing the Tip .....   | 18 |
| Providing a Suitable Mechanical Mounting and Installation Environment..... | 21 |
| Installing the Actuator in a Mechanical Mounting.....                      | 23 |

### 5.1 General Notes on Installation

#### NOTICE

**Torque on pusher!**

While the end piece is being screwed on or off, the torque is transferred to the drive of the linear actuator via the pusher and can damage the drive.

- Avoid torques to the pusher.
- When screwing an end piece on or off, attach the pusher to the wrench flats using an open-end wrench.

#### NOTICE

**Cable break!**

A cable break leads to a failure of the linear actuator.

- Install the linear actuator so that the cable is not bent or squeezed too severely during operation.

#### NOTICE

**Increased friction!**

Lateral forces that affect the pusher of the linear actuator increase the friction on the internal drive components. Increased friction impairs the motion of the pusher and increases wear on the drive components.

- Avoid lateral forces on the tip and on the pusher of the M-235.

**NOTICE****Heating up of the M-235 during operation!**

The heat produced during operation of the M-235 can affect your application.

- Install the M-235 so that your application is not affected by the dissipating heat.

**INFORMATION**

Linear actuators with DC gear motors are equipped with integrated signal drivers for cable lengths of  $\leq 10$  m between linear actuator and motor controller.

## 5.2 Changing the Tip

**INFORMATION**

The supplied end pieces make it possible to realize different mechanical connections to a load:

- A flat end piece allows a wide-area connection to a load.
- A spherical end piece allows a punctiform connection to a load.

To achieve optimum repeatability:

- Use an end piece.

Make sure that the selected end piece is completely screwed in and does not have any backlash.

The end piece is used to establish contact with the load. A flat end piece is delivered pre-assembled; a spherical end piece is also provided.

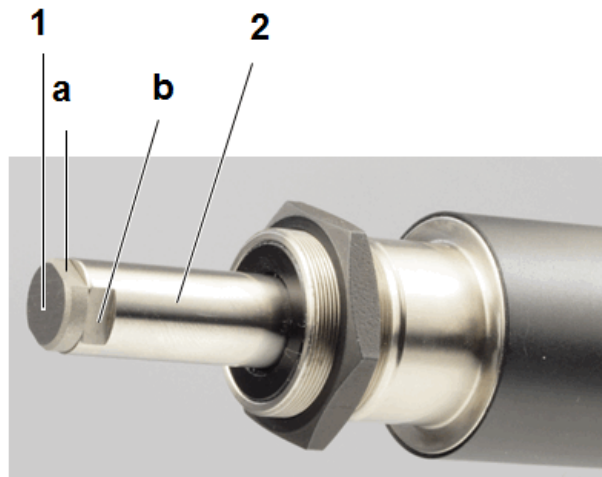


Figure 3: Mounted end piece (flat)

- 1 End piece with  
(a) wrench flat
- 2 Pusher with  
(b) wrench flat

### Prerequisites

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ You have made the M-235 accessible for changing the end piece.
- ✓ The pusher has been moved out so far that you can easily reach the wrench flat with a open-end wrench. Upon delivery, the pusher has been moved out far enough.

### Tools and accessories

- Supplied end piece (p. 12)
- Two AF 8 open-end wrenches

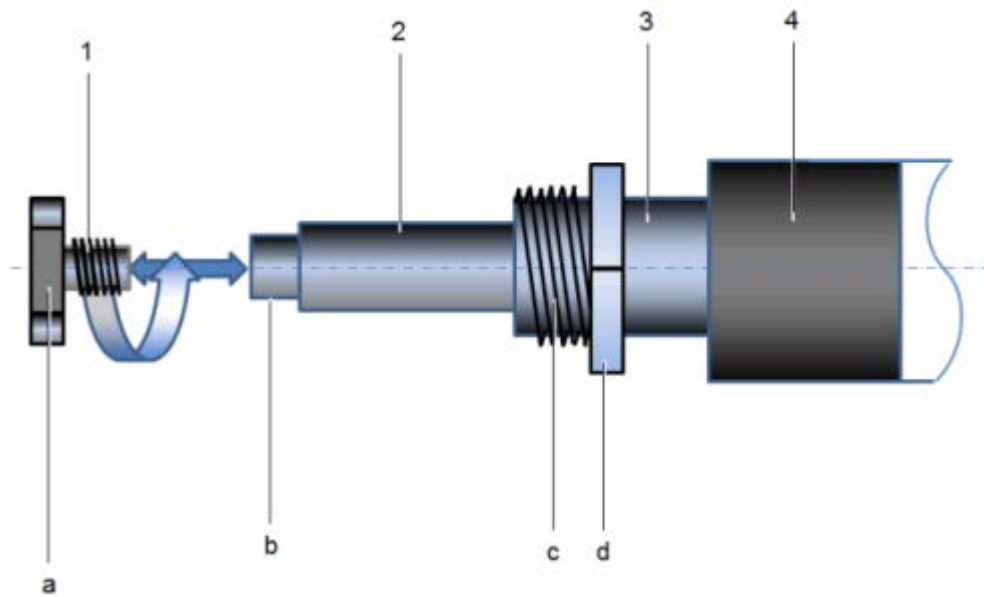


Figure 4: Changing the end piece, schematic

- 1 End piece (flat) with  
(a) wrench flat
- 2 Non-turning pusher with  
(b) wrench flat
- 3 Mounting shaft with  
(b) thread (for clamp connection, M20)  
(c) mounting nut
- 4 Sleeve

### Changing the end piece

1. Attach the pusher: apply an AF 8 open-end wrench to the wrench flats of the pusher.
2. Manually unscrew the end piece to be replaced from the pusher of the M-235. If this is not successful, use a second AF 8 open-end wrench.
3. Screw the new tip by hand into the pusher of the M-235.
4. Remove the pusher from the open-end wrench.

### 5.3 Providing a Suitable Mechanical Mounting and Installation Environment

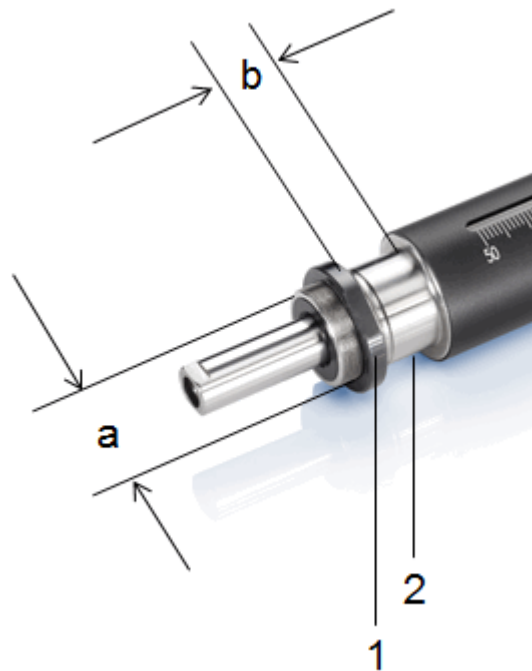


Figure 5: Relevant components and dimensions for installation in the mechanical mounting (schematic)

- 1 Mounting nut, M20
- 2 Mounting shaft with
  - (a) diameter: 20 mm
  - (b) clamping width: 12 mm to 18 mm usable

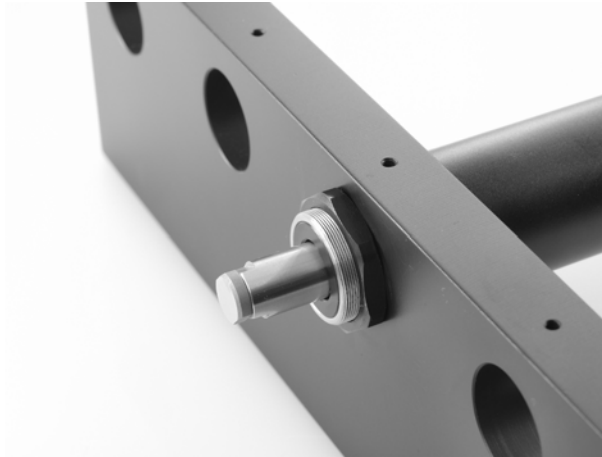


Figure 6: Example for the installation of a linear actuator (here: an M-235)

A suitable mechanical mounting and installation environment are necessary for the proper use of the actuator.

- Make sure that the following conditions have been met:
  - Material and statics of the mounting are designed so that the static and dynamic forces that occur can be safely and continuously managed.
  - The dimensions of the mounting are adapted to the dimensions of the actuator (see above figures and dimensions (p. 45)).
  - The intended motions of the pusher and the load must not be inhibited by the dimensions of the installation environment.
- Take into account the following specifications as well when planning the application and installing the actuator:
  - Dimensions of the selected end piece (see Dimensions (p. 45))
  - Travel range: maximum 20 mm (M-235.2xx models) or 50 mm (M-235.5xx models)
  - Space requirements for a kink-free and proper guiding of the connection cable and additional motor cables
  - Length of the connection cable (approx. 0.5 m) and additional motor cables (3 m or 10 m)
  - Position of the position display of the actuator when it is to be read during operation.
- If the limit switches of the actuator cannot be reached with the planned minimum and maximum displacements: Make sure that the actuator and the load **only move within the planned range**. Suitable measures:

- Corresponding programming of the controller
- Emergency off switch
- Automatic shutdown systems
- Avoid or label danger areas that result from the installation of the actuator and from use, in accordance with the legal regulations (e.g. risk of crushing in the case of heavy moving loads, fast actuator motions and/or high drive torques).

The complete dimensions of the actuator and relevant individual parts can be found in the figures in the section Dimensions (p. 45).

## 5.4 Installing the Actuator in a Mechanical Mounting

### NOTICE



#### **Incorrect tightening torque of the mounting nut!**

The motion of the pusher can be hindered by a mounting nut that has been tightened too strongly. This reduces the positioning accuracy.

Tighten the mounting nut to a maximum torque of 1 Nm.

### INFORMATION

To achieve an optimum repeatability, the mounting shaft must not have any backlash.

- During mounting, make sure that there is a faultless connection between the actuator and the mechanical mounting.

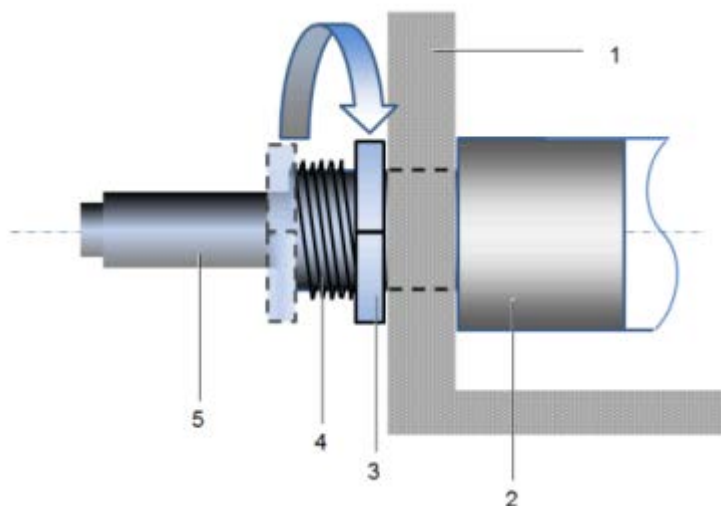


Figure 7: Clamp connection (schematic)

- 1 Mechanical mounting
- 2 Sleeve
- 3 Mounting nut, M20
- 4 Mounting shaft with thread
- 5 Pusher with end piece (flat)

We recommend installing the actuator in the mechanical mounting with a clamp connection. The following instructions refer to this case.

### Prerequisites

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ You have provided your application with a suitable mounting for the mounting shaft of the actuator (p. 21).

### Tools and accessories

- Open-end wrench SW 24

### Installing the actuator

1. Loosen the mounting nut on the mounting shaft of the actuator.
2. Position the actuator in the mounting of your application.
3. If necessary, stick a suitable flat washer or a suitable spring washer on the mounting shaft.

4. Manually screw the mounting nut into the thread of the mounting shaft with a few rotations.
5. To clamp the actuator in the mounting, tighten the mounting nut using the open-end wrench until you feel a resistance. The torque must **not** exceed 1 Nm!
6. Check that the actuator is correctly fitted in the mounting.

### 5.4.1 Connecting Cables to Models with Stepper Motor

#### Prerequisites

- ✓ You have read and understood the General Notes on Installation (p. 17).
- ✓ The motor cable is not connected to the controller.

#### Tools and accessories

- Suitable motor cable from PI, e.g.:
  - Motor cable C-815.38, 3 m, Sub-D, 15-pin (m/f), in the scope of delivery (p. 12).
  - C-815.83 motor cable, 10 m, Sub-D, 15-pin (m/f), available as optional accessory (p. 12).

#### Connecting cables to models with stepper motor

1. Connect the socket of the motor cable to the Sub-D panel plug, 15-pin (m) of the linear actuator.
2. Secure the socket with the two integrated screws against accidental disconnection from the linear actuator.



## 6 Start-Up

### In this Chapter

|                                 |    |
|---------------------------------|----|
| General Notes on Start-Up ..... | 27 |
| Starting Up the Actuator .....  | 29 |

### 6.1 General Notes on Start-Up

#### CAUTION



**Unintentional motion of the linear actuator while connecting it to the motor controller!**

- Do not place any objects in areas where they can get caught by moving parts.
- Keep your fingers at a safe distance from the motion range of the linear actuator.

#### NOTICE



**Damage if a wrong motor controller is connected!**

Connecting a linear actuator to an unsuitable controller can cause damage to the linear actuator or controller.

- Connect a linear actuator with DC motor to a DC motor controller only.
- Connect a linear actuator with stepper motor to a stepper motor controller only.

#### NOTICE



**Damage due to the pusher crashing into the hard stop!**

When the limit switches are deactivated, the motion of the pusher is aborted by the hard stop and the M-235 can be damaged.

- Do **not** deactivate the limit switches in the software.
- Test limit switch operation at low velocities only.

**NOTICE****Damage or major wear to the mechanical system as a result of high acceleration!**

- In the event of a malfunction of the motor controller, stop the motion immediately.
- Ensure that the end of the travel range is approached at low velocity.
- Set your control signal so that the moving part does not stop abruptly or try to continue moving at the end of the travel range.
- Determine the maximum velocity for your application.

**NOTICE****Damage from unsuitable controllers and PC software!**

Unsuitable controllers and PC software can cause damage to the actuator.

- If you use controllers and software from other manufacturers, **before** starting up the actuator, check the technical data to make sure that they are suitable!

**INFORMATION**

The maximum velocity for a linear actuator with a stepper motor should be determined in the application. If the commanded velocity is too high, the stepper motor might stop without the controller detecting this condition.

**INFORMATION**

The handwheel of a linear actuator with stepper motor can be used to manually retract and extend the pusher. Manually triggered changes in the position of the pusher are **not** recognized by the connected controller.

**INFORMATION**

The repeatability of the positioning is only ensured when the reference point switch is always approached from the same side. Motor controllers from PI fulfill this requirement with their automatic direction detection for reference moves to the reference point switch.

**INFORMATION**

For models with DC motors:

Unsuitable settings made to the servo-control parameters can impair the performance of the M-235. The consequences of this can be expressed as follows:

- Oscillations
- Imprecise approach of the position
- Settling time is too long
- If the performance of the M-235 is not satisfactory, check the settings for the servo-control parameters of your controller.

**INFORMATION**

Moving the pusher outwards corresponds to the positive direction of motion.

## 6.2 Starting Up the Actuator

In the following, a PC with PC software is used as the peripheral control equipment of the controller.

**Prerequisites**

- ✓ You have read and understood the General Notes on Start-Up (p. 27).
- ✓ You have correctly installed the actuator (p. 17).
- ✓ You have read and understood the user manual of the used controller.
- ✓ You have read and understood the manual of the used PC software.

**Accessories**

- Suitable controller (p. 12) - motor controller card for PC installation or stand-alone device incl. connection cable to PC.
- PC
- PC software for the controller (for PI controllers: included in their scope of delivery)
- If necessary, suitable motor cable from PI, e.g.:
  - Motor cable C-815.38, 3 m, Sub-D, 15-pin (m/f), in the scope of delivery (p. 12).

- Motor cable C-815.83, 10 m, Sub-D, 15-pin (m/f), available as optional accessory (p. 12).

### Starting up the actuator

1. If you use a motor controller card (e.g. C-843 from PI), make sure that it is properly installed or install it (see the user manual of the motor controller card).
2. If suitable and current PC software for the controller is not on your PC yet, install the PC software (see the user manual of the controller or the software).
3. If you do **not** use a motor controller card, connect the PC with the external controller using a suitable cable.  
For PI products: the cable required for this is included in the scope of delivery.
4. Connect the actuator with the controller:
  - a) Determine the minimum necessary cable length between the actuator and the controller.
  - b) Connect the connector of the connection cable with the Sub-D socket of the controller or a corresponding adapter (according to the determined length, see above) either directly or by interposing an additional motor cable.
  - c) Secure all connections with the integrated screws against accidental disconnection.
  - d) Remove or label resulting danger areas in accordance with the valid legal regulations and directives.
5. Start up the controller (see user manual of the controller).
6. Configure the controller using the PC software for the used actuator (see the user manual of the controller and the PC software):
  - If you use a PI controller: select the entry in the stage database that precisely matches the actuator version used, see the list of available entries (p. 31).
  - If you use a controller from another manufacturer: Enter the parameters in the corresponding PC software that precisely match the actuator version used; see overview of the operating parameters for DC motor controllers (p. 33) or stepper motor controllers (p. 34).
7. Start a few motion cycles for testing purposes (see user manual of the controller).

### 6.2.1 M-235 Entries in the Stage Database of PI

For motor controllers from PI you can select the connected linear actuator from a stage database in the respective PC software. The appropriate operating parameters are thus loaded into the motor controller. You can find a detailed description in the user manual for the motor controller or in the manual for the PC software used.

The following table shows the linear actuators and their names in the stage database.

| M-235     | Name in the stage database | Specifications in the stage database (selection)   |
|-----------|----------------------------|--|
| M-235.2DG | M-235.2DG                  | Motor type: DC motor; conservative set of servo-control parameters (adjustable initial values); gear ratio taken into account; travel range 20 mm; limit switches active high    |
|           | M-235.2DG-PWM              | Like the M-235.2DG except for parameters for PWM output, for use with C-842.AP1 PWM-to-analog adapter box  |
| M-235.5DG | M-235.5DG-NEW              | Motor type: DC motor; conservative set of servo-control parameters (adjustable initial values); gear ratio taken into account; travel range 50 mm; limit switches active high    |
|           | M-235.5DG                  | Like the M-235.5DG-NEW, however without reference point switch – use only for stages without reference point switch (manufactured until February 2003)                           |
|           | M-235.5DG-NEW-P            | Like the M-235.5DG-NEW except for parameters for PWM output, for use with C-842.AP1 PWM-to-analog adapter box  |
|           | M-235.5DG-PWM              | Like the M-235.5DG-NEW-P, however without reference point switch – use only for stages without reference point switch (manufactured until February 2003)                         |
| M-235.2DD | M-235.2DD                  | Motor type: DC motor; conservative set of servo-control parameters (adjustable initial values); no gear ratio since direct drive; travel range 20 mm; limit switches active high |
|           | M-235.2DD-PWM              | Like the M-235.2DD except for parameters for PWM output, for use with C-842.AP1 PWM-to-analog adapter box  |

| M-235     | Name in the stage database | Specifications in the stage database (selection)   |
|-----------|----------------------------|--|
| M-235.5DD | M-235.5DD-NEW              | Motor type: DC motor; conservative set of servo-control parameters (adjustable initial values); no gear ratio since direct drive; travel range 50 mm; limit switches active high |
|           | M-235.5DD                  | Like the M-235.5DD-NEW, however without reference point switch – use only for stages without reference point switch (manufactured until February 2003)                           |
|           | M-235.5DD-NEW-P            | Like the M-235.5DD-NEW except for parameters for PWM output, for use with C-842.AP1 PWM-to-analog adapter box  |
|           | M-235.5DD-PWM              | Like the M-235.5DD-NEW-P, however without reference point switch – use only for stages without reference point switch (manufactured until February 2003)                         |
| M-235.2VD | M-235.2VD                  | Like M-235.2DD   |
| M-235.5VD | M-235.5VD                  | Like M-235.5DD-NEW   |
|           | M-235.5VD-PWM              | Like the M-235.5DD-NEW except for parameters for PWM output, for use with C-842.AP1 PWM-to-analog adapter box  |
| M-235.2VG | M-235.2VG                  | Like M-235.2DG   |
| M-235.5VG | M-235.5VG                  | Like M-235.5DG-NEW   |
| M-235.22S | M-235.22S                  | Motor type: stepper motor; parameters for operating current, holding current and holding current delay; travel range 20 mm; limit switches active low                            |
| M-235.52S | M-235.52S                  | Motor type: stepper motor; parameters for operating current, holding current and holding current delay; travel range 50 mm; limit switches active low                            |

## 6.2.2 Operating Parameters of the Models with DC Motor

If you use a DC motor controller from a third-party supplier, it may be necessary to enter operating parameters to adjust the used linear actuator.

| Parameter             | M-235 version |             |                           | Unit                  |
|-----------------------|---------------|-------------|---------------------------|-----------------------|
|                       | .2DG, .2VG    | .5DG, .5VG  | .2DD, .2VD,<br>.5DD, .5VD |                       |
| P-term                | 300           | 150         | 250                       | -                     |
| I-term                | 300           | 240         | 25                        | -                     |
| D-term                | 500           | 120         | 250                       | -                     |
| I-limit               | 2000          | 2000        | 2000                      | -                     |
| Maximum acceleration  | 1821202       | 1821202     | 61440                     | counts/s <sup>2</sup> |
| Maximum velocity      | 2             | 2           | 30                        | mm/s                  |
| Maximum velocity      | 121413        | 121413      | 61440                     | counts/s              |
| Gear reduction        | 29.6:1        | 29.6:1      | -                         | -                     |
| Encoder resolution    | 2048          | 2048        | 2048                      | -                     |
| Limit switch polarity | Active high   | Active high | Active high               | -                     |

### 6.2.3 Operating Parameters of the Models with Stepper Motor

If you use a stepper motor controller from a third-party supplier, it may be necessary to enter operating parameters to adjust the used linear actuator.

| Parameter                        | M-235<br>versions .22S and .52S | Unit                 |
|----------------------------------|---------------------------------|----------------------|
| <b>Recommended start values:</b> |                                 |                      |
| Holding current                  | 200                             | mA                   |
| Operating current                | 600                             | mA                   |
| Holding current delay            | 500                             | ms                   |
| Max. motor current               | 850                             | mA                   |
| Max. acceleration                | 20000                           | steps/s <sup>2</sup> |
| Max. velocity                    | 20                              | mm/s                 |
| Max. velocity                    | 8000                            | steps/s              |
| <b>Hardware properties:</b>      |                                 |                      |
| Limit switch polarity            | Active low                      | -                    |
| Full steps                       | 400                             | steps/revolution     |
| Phase resistance                 | 6.6                             | ohm                  |
| Max. phase current, bipolar      | 850                             | mA                   |

## 7 Maintenance

### In this Chapter

|                                   |    |
|-----------------------------------|----|
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| Lubricating the M-235.....        | 35 |
| Cleaning the M-235 .....          | 36 |

### 7.1 General Notes on Maintenance

#### NOTICE



#### Damage due to improper maintenance!

The M-235 can become misaligned as a result of improper maintenance.

- Do not loosen any sealed screws.

### 7.2 Lubricating the M-235

Depending on the operational conditions and the period of use of the linear actuator, the following maintenance measures are required.

#### Spreading lubricant

- If you operate the M-235 continuously on a small travel range (<20% of the entire travel range), perform a maintenance run every 2000 motion cycles across the entire travel range.

#### Lubrication

Under laboratory conditions, the linear actuator needs extra lubrication in exceptional cases only. For continuous industrial use the lubrication intervals must be defined individually.

- Do not lubricate the M-235 without consulting our customer service department (p. 39).
- To lubricate, follow the instructions given in the maintenance manual which you can obtain from our customer service department.

## 7.3 Cleaning the M-235

### Prerequisites

- ✓ You have disconnected the linear actuator from the controller.

### Cleaning the linear actuator

Only when the linear actuator is **not** used in vacuum:

- When necessary, clean the linear actuator surface with a towel lightly dampened with a mild cleanser or disinfectant.
- Do **not** use any organic solvents.

Only when the linear actuator is used in vacuum:

- Only touch the linear actuator with powder-free gloves.
- If necessary, wipe the linear actuator clean.

## 8 Troubleshooting

| Problem   | Possible Causes  | Solution   |
|---|--|--|
| Reduced positioning accuracy  | Mounting nut is fastened too tight   | ➤ Tighten the mounting nut to a maximum torque of 1 Nm.  |
|   | Drive damaged due to torque on pusher  | ➤ Contact our customer service department  |
| Functional impairment after system modification                       | <ul style="list-style-type: none"> <li>▪ Controller has been replaced</li> <li>▪ M-235 has been replaced with another model</li> </ul>   | Controller from PI: <ul style="list-style-type: none"> <li>➤ Load the parameters from the stage database that correspond to the combination of controller and M-235 model (p. 29).</li> </ul> Controller from a third-party supplier: <ul style="list-style-type: none"> <li>➤ Check the operating parameters</li> </ul> |
| The mechanical system does not move                                   | The cable is not connected correctly or is faulty  | ➤ Check the connecting cable.  |
|   | Lateral forces are affecting the pusher  | Lateral forces increase the friction on the internal drive components. <ul style="list-style-type: none"> <li>➤ Avoid lateral forces on the tip and on the pusher of the M-235.</li> </ul>   |
| The mechanical system does not move, but generates operating noise    | Values for the velocity, acceleration and/or load are too high   | <ul style="list-style-type: none"> <li>➤ Reduce the velocity.</li> <li>➤ Reduce the acceleration.</li> <li>➤ Reduce the load on the mechanical system.</li> </ul>  |
| The mechanical system did not stop in time and ran into the hard stop | <ul style="list-style-type: none"> <li>▪ Velocity is too high (see chapter Limit Switches p. 13)</li> <li>▪ Limit switch is defective</li> <li>▪ Controller ignores the limit switch signal</li> </ul> | <ol style="list-style-type: none"> <li>1. Stop the motor.</li> <li>2. Command the mechanical system away from the hard stop.</li> <li>3. Check the settings of the controller for the limit switch processing.</li> </ol>  |

If the problem that occurred with your system is not listed in the table above or it cannot be solved as described, contact our customer service department (p. 39).



## 9 Customer Service

For inquiries and orders, contact your PI sales engineer or send us an e-mail (<mailto:info@pi.ws>).

If you have questions concerning your system, have the following information ready:

- Product codes and serial numbers of all products in the system
- Firmware version of the controller (if present)
- Version of the driver or the software (if present)
- Operating system on the PC (if present)

The latest versions of the relevant user manuals for your system are available for download on our website (<http://www.pi.ws>).



## 10 Technical Data

### In this Chapter

|                      |    |
|----------------------|----|
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| Pin Assignment.....  | 48 |

## 10.1 Specifications

### 10.1.1 Data Table

|                               | M-235.2DG /<br>M-235.5DG                 | M-235.2DD /<br>M-235.5DD | M-235.22S /<br>M-235.52S | Unit       | Tolerance |
|-------------------------------|--|--------------------------|--------------------------|------------|-----------|
|                               | High resolution and force, DC gear motor | High dynamics            | With stepper motor       |            |           |
| <b>Motion and positioning</b> |  |                          |                          |            |           |
| Travel range                  | 20 / 50                                  | 20 / 50                  | 20 / 50                  | mm         |           |
| Integrated sensor             | Rotary encoder                           | Rotary encoder           | –                        |            |           |
| Sensor resolution             | 2048                                     | 2048                     | –                        | cts./rev.  |           |
| Design resolution             | 0.016                                    | 0.5                      | 0.156                    | μm         | typ.      |
| Min. incremental motion       | 0.1                                      | 0.5                      | 0.2                      | μm         | typ.      |
| Backlash                      | 2  | 2                        | 2                        | μm         | typ.      |
| Unidirectional repeatability  | ±0.1                                     | ±0.5                     | ±0.2                     | μm         |           |
| Velocity                      | 2.6                                      | 30                       | 20                       | mm/s       | max.      |
| <b>Mechanical properties</b>  |  |                          |                          |            |           |
| Gear ratio                    | 29.6:1                                   | –                        | –                        |            |           |
| Motor resolution              | –  | –                        | 6400*                    | steps/rev. |           |
| Push / pull force             | 120                                      | 50                       | 100**                    | N          | max.      |
| Permissible lateral force     | 8  | 8                        | 8                        | N          | max.      |

|                                     | M-235.2DG /<br>M-235.5DG   | M-235.2DD /<br>M-235.5DD   | M-235.22S /<br>M-235.52S  | Unit | Tolerance   |
|-------------------------------------|--|--|---------------------------|------|-------------|
| <b>Drive properties</b>             |  |  |                           |      |             |
| Motor type                          | DC motor,<br>gearhead  | DC motor   | 2-phase<br>stepper motor* |      |             |
| Operating voltage                   | 0 to $\pm 12$  | 0 to $\pm 12$  | 24                        | V    |             |
| Electrical power                    | 4  | 17   | –                         | W    | nominal     |
| Limit / reference point<br>switches | Hall-effect  | Hall-effect  | Hall-effect               |      |             |
| <b>Miscellaneous</b>                |  |  |                           |      |             |
| Operating temperature<br>range      | -20 to 65  | -20 to 65  | -20 to 65                 | °C   |             |
| Material                            | Aluminum anodized, chrome steel                                  |  |                           |      |             |
| Mass                                | 0.55 / 0.7   | 0.5 / 0.65   | 0.65 / 0.8                | kg   | $\pm 5$ %   |
| Cable length                        | 0.5 + 3 m extension cable (included)                             |  |                           | m    | $\pm 10$ mm |
| Connector                           | 15-pin sub-D,<br>incl. encoder<br>driver                         | 15-pin sub-D,<br>incl. encoder<br>driver                         | Sub-D, 15-pin             |      |             |
| Recommended<br>controller/driver    | C-863 single-<br>axis<br>C-843 PCI<br>board, for up to<br>4 axes | C-863 single-<br>axis<br>C-843 PCI<br>board, for up to<br>4 axes | C-663 single-<br>axis     |      |             |

Specifications for vacuum versions can differ.

Ask about custom designs!

\* 24 V chopper voltage, max. 0.8 A/phase; 400 full steps/rev., motor resolution with C-663 stepper motor controller.

\*\* At a velocity of up to 10 mm/s.

### 10.1.2 Ambient Conditions and Classifications

The following ambient conditions and classifications must be observed for the M-235:

|   |   |
|---|---|
| Area of application                         | For indoor use only   |
| Maximum altitude                            | 2000 m  |
| Relative humidity                           | Highest relative humidity 80% for temperatures up to 31°C<br>Decreasing linearly to 50% relative humidity at 40°C |
| Storage temperature                         | 0°C to 80°C   |
| Transport temperature                       | 0°C to 80°C   |
| Supply fluctuations                         | Not more than $\pm 10\%$ of the nominal voltage   |
| Degree of pollution                         | 2   |
| Degree of protection according to IEC 60529 | IP40  |

### 10.1.3 Limit Switch Specifications

|                |   |
|----------------|---|
| Type           | Magnetic (Hall-effect) sensor   |
| Supply voltage | +5 V/ground   |
| Signal output  | TTL level   |
| Signal logic   | <p>The signal level changes when passing the limit switch. The signal logic depends on the model type:</p> <ul style="list-style-type: none"> <li>▪ Models with DC motor: <b>active high</b>. That means: <ul style="list-style-type: none"> <li>– Normal motor operation: low (0 V)</li> <li>– Limit switch reached: high (+5 V)</li> </ul> </li> <li>▪ Models with stepper motor: <b>active low</b>. That means: <ul style="list-style-type: none"> <li>– Normal motor operation: high (+5 V)</li> <li>– Limit switch reached: low (0 V)</li> </ul> </li> </ul> |

### 10.1.4 Reference Point Switch Specifications

|                |   |
|----------------|---|
| Type           | Magnetic (Hall-effect) sensor   |
| Supply voltage | +5 V/GND  |
| Signal output  | TTL level   |
| Signal logic   | Direction sensing by means of different signal levels on the left and right side of the reference point switch: The signal level changes from 0 to +5 V when the reference point switch is passed |

### 10.1.5 Specifications for Vacuum-Compatible Versions

The specifications of the vacuum-compatible versions M-235.2VG, M-235.2VD, M-235.5VG and M-235.5VD correspond to the specifications of the versions M-235.2DG, M-235.2DD, M-235.5DG respectively.

|                       | M-235.xVG   | M-235.xVD   |
|-----------------------|---|---|
| Drive                 |   |   |
| Motor                 | Manufacturer: Faulhaber<br>Motor type: 2224R012<br>Gear: 22/5<br>Ratio: 29.6:1<br>Encoder: IE2-512  | Manufacturer: Faulhaber<br>Motor type: 2342S024<br><br>Encoder: IE2-512 |
| Materials used        |   |   |
| Sleeve                | Stainless steel, aluminum alloy (AlMgSi1) anodized or uncoated  |   |
| Bearing               | Steel   |   |
| Drivetrain elements   | Ball screw: steel   |   |
| Electrical components | Cable insulation: Teflon (PTFE)<br>Shrink tubing: Kynar<br>Solder: Sn95.5Ag3.8Cu0.7<br>Connector: AMP HD20, Lemo<br>Connector shell: die-cast zinc, Ni coated |   |
| Grease                | Molykote HP-300,Torrlube, Barrierta L55/2   |   |
| Sealing compound      | Varian TorrSeal   |   |
| Other                 |   |   |
| Bakeout temperature   | 80°C (176°F)  |   |

## 10.2 Dimensions

### 10.2.1 M-235.xDx und M-235.xVx

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

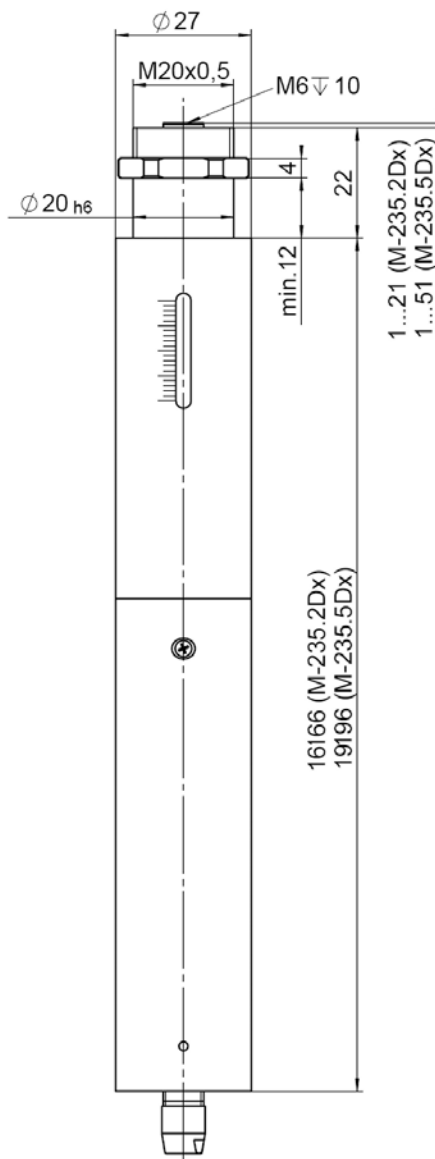


Figure 8: M-235.xDx and M-235.xVx, dimensions in mm

### 10.2.2 M-235.x2S

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

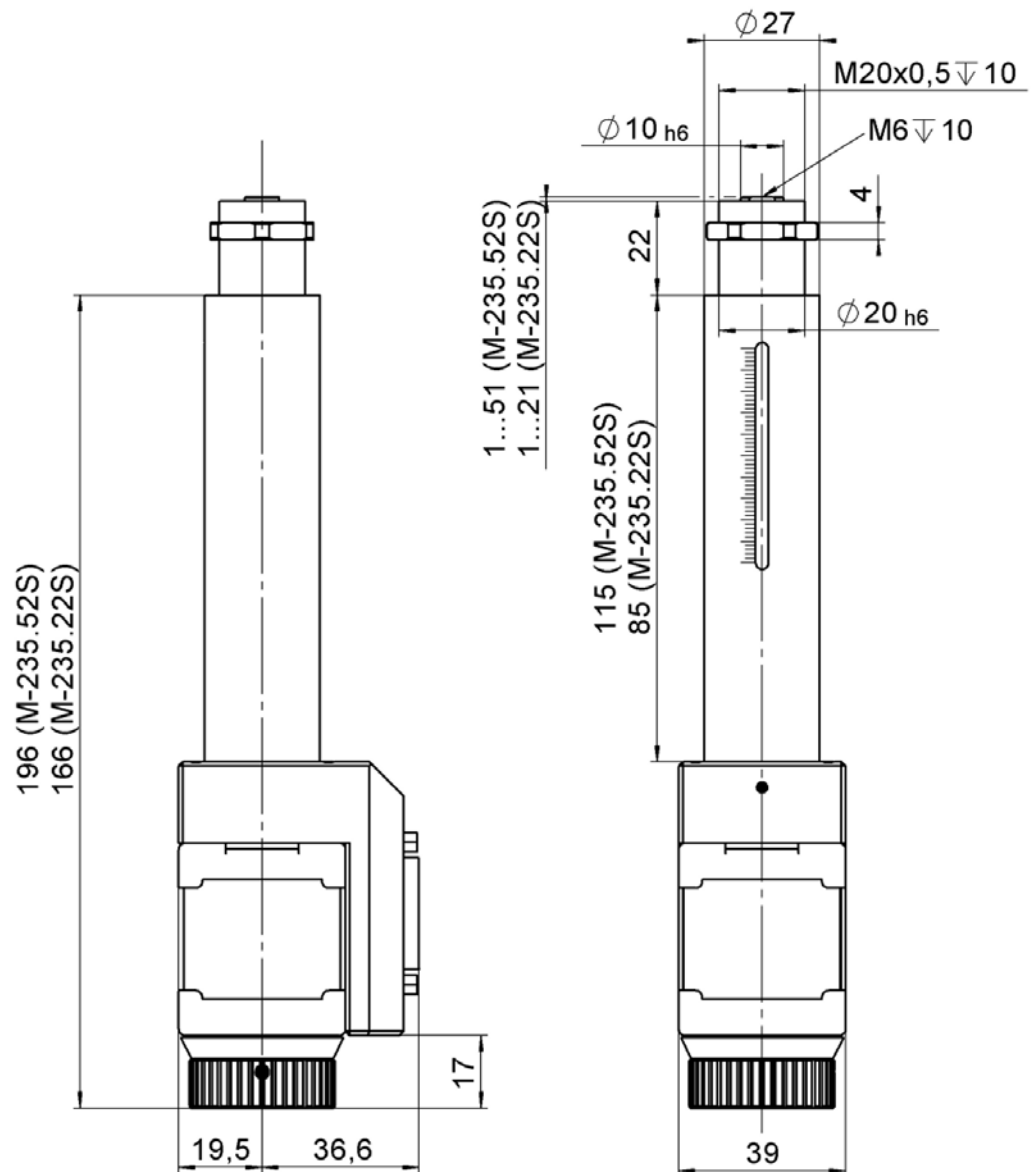


Figure 9: M-235.x2S, dimensions in mm

### 10.2.3 End Pieces

Dimensions in mm. Note that the decimal places are separated by a comma in the drawings.

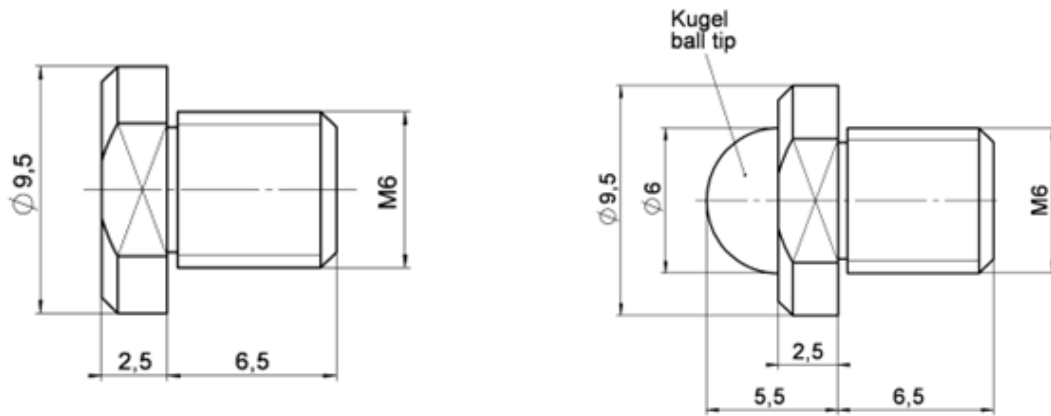


Figure 10: Low-profile top piece (left) and spherical end piece (right)

## 10.3 Pin Assignment

### 10.3.1 Models with DC Gear Motor

**Connector: Sub-D 15-pin (m)**

| Pin no. | Function                                   |
|---------|--|
| 1       | Internal                                   |
| 9       | Input: Motor (-)                           |
| 2       | Input: Motor (+)                           |
| 10      | Internal                                   |
| 3       | Internal                                   |
| 11      | Internal                                   |
| 4       | Input: +5 V supply from controller         |
| 12      | Output: Limit switch signal, negative side |
| 5       | Output: Limit switch signal, positive side |
| 13      | Output: Reference point switch signal      |
| 6       | GND (limit switch and logic)               |
| 14      | Output: Encoder A (+)                      |
| 7       | Output: Encoder A (-)                      |
| 15      | Output: Encoder B (+)                      |
| 8       | Output: Encoder B (-)                      |

### 10.3.2 Models with Stepper Motor

**Connector: Sub-D 15-pin (m)**

| Pin no. | Function                                   |
|---------|--|
| 1       | Input: Phase 1a                            |
| 9       | Input: Phase 1b                            |
| 2       | Input: Phase 2a                            |
| 10      | Input: Phase 2b                            |
| 3       | Not connected                              |
| 11      | Not connected                              |
| 4       | Not connected                              |
| 12      | Not connected                              |
| 5       | Not connected                              |
| 13      | Not connected                              |
| 6       | Input: +5 V supply from controller         |
| 14      | Output: Limit switch signal, positive side |
| 7       | GND  |
| 15      | Output: Reference point switch signal      |
| 8       | Output: Limit switch signal, negative side |



## 11 Old Equipment Disposal

Since 13 August 2005, in accordance with the EU directive 2002/96/EC (WEEE), electrical and electronic equipment can no longer be disposed of in the member states of the EU with other wastes.

When disposing of your old equipment, observe the international, national and local rules and regulations.

To meet the manufacturer's product responsibility with regard to this product, Physik Instrumente (PI) GmbH & Co. KG ensures environmentally correct disposal of old PI equipment that was first put into circulation after 13 August 2005, free of charge.

If you have old PI equipment, you can send it postage-free to the following address:

Physik Instrumente (PI) GmbH & Co. KG  
Auf der Römerstr. 1  
D-76228 Karlsruhe, Germany





## 12 EU Declaration of Conformity

PI

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### Declaration of Conformity

according to DIN EN ISO/IEC 17050-1

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**Manufacturer:** Physik Instrumente (PI)  
GmbH & Co. KG

**Manufacturer's Address:** Auf der Roemerstraße 1  
D-76228 Karlsruhe,  
Germany

CE

**The manufacturer hereby declares that the product**

**Product Name:** Heavy-Duty Precision Linear Actuator

**Model Numbers:** M-235

**Product Options:** all

complies with all relevant provisions of the **Machinery Directive (2006/42/EC)**.  
Furthermore, it complies with all provisions of the **Low Voltage Directive (2006/95/EC)** and the **EMC Directive (2004/108/EC)**.

**The applied standards certifying the conformity are listed below.**

**Safety of Machinery:** EN 12100-1, EN-12100-2


**Safety (Low Voltage Directive):** EN 61010-1

**Electromagnetic Emission:** EN 61000-6-3, EN 55011

**Electromagnetic Immunity:** EN 61000-6-1

The person authorized to compile the technical file is: Wolfgang Schobel  
Address: see manufacturer's address

April 07, 2011  
Karlsruhe, Germany

  
 Dr. Karl Spanner  
 President

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PIEZO NANO POSITIONING  
